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DATA, PRECONCEIVED NOTIONS AND METHODS: THE CASE OF POPULATION SIZES OF COMMON BREEDING BIRDS IN SPAIN

DATOS, IDEAS PRECONCEBIDAS Y MÉTODOS: EL CASO DEL TAMAÑO POBLACIONAL DE LAS AVES COMUNES REPRODUCTORAS EN ESPAÑA

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SUMMARY.—Estimating population sizes of birds is of fundamental importance in species-oriented conservation and management. Worryingly, discrepancies among different population estimates are widespread in ornithological literature. A complementary review to that carried out by Murgui (2011) on the available literature on national population sizes of Spanish birds is developed, putting the accent on data quality and methods used (geographical bias in sampling effort, sample sizes, census methods, detectability problems, consideration of the cryptic fraction of population not included in breeding pairs, how the number of breeding pairs is obtained, extrapolation methodologies, etc). I conclude with a positive, conciliatory, view about large-scale population estimates, where limitations of previous works enlighten future research and sampling programs.

Key words: bird abundance, census methods, detectability, large-scale population estimates, Spain.

RESUMEN.—Las estimas de los tamaños de población son de gran importancia en la biología de la conservación y gestión de poblaciones centrada en las especies. En este trabajo se desarrolla una revisión complementaria de la literatura técnica disponible sobre la estima de los tamaños de población de aves reproductoras comunes en España, poniendo el énfasis en la calidad de los datos obtenidos y métodos utilizados, en vez de en la mera comparación de cifras (sesgos geográficos en la obtención de datos, tamaños muestrales, consideración de la fracción de la población que no establece parejas reproductivas, estima del número de parejas reproductoras a partir del número de individuos censados, métodos de extrapolación a las áreas no censadas, etc.). Se concluye con una visión positiva y conciliadora de la información existente, en la que las limitaciones de los trabajos previos guían el desarrollo de futuros estudios.

Palabras clave: abundancia de aves, detectabilidad, España, estimas de población existente, método de censo.

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"It's a hard road …
even my best friends they don't know
that my job is turning lead into gold"

Philosophers stone – Van Morrison

INTRODUCTION

Estimating population sizes of birds is of fundamental importance in species-oriented conservation and management. Worryingly, discrepancies among different population estimates are widespread in ornithological literature. Several sources of error contribute to these discrepancies, such as geographical bias in sampling effort, detectability problems, consideration of the cryptic fraction of population not included in breeding pairs, etc (e.g., Hildén and Laine, 1985; Newson *et al.*, 2008). These discrepancies are of particular concern in areas of high biodiversity and importance for many taxa, for which we have no baseline knowledge of actual population sizes for the most widespread species and, therefore, it is difficult to know which population estimates are more accurate. One of these areas for bird biodiversity is the Iberian Peninsula, where many common bird species have their European strongholds according to their restricted distribution (e.g., *Alectoris rufa*, *Clamator glandarius*, *Galerida theklae*, *Cecropis daurica*, *Sylvia undata*, *Cyanopica cooki*, *Sturnus unicolor*) or high abundance (e.g., *Burhinus oedicnemus*, *Merops apiaster*, *Upupa epops*, *Anthus campestris*, *Phylloscopus bonelli*, *Sylvia hortensis*, *Serinus serinus*; Hagemeijer & Blair, 1997; BirdLife, 2004).

In a recent work comparing population estimates for Spanish common birds using two different sources (BirdLife, 2004 and Carrascal and Palomino, 2008), Murgui (2011) concludes that although the estimated relative abundance of bird species was similar in both works, the absolute values differed up to 30-fold and the most recent national estimates were on average nearly five times as high as the earlier ones, and more than ten times greater for 19% of the 95 species considered. Murgui (2011) points out that differences in sampling design and data analyses were probably responsible for these discrepancies, but it is probable that population estimates in Carrascal and Palomino (2008) are sometimes debatable. He also states that this is a problem of considerable concern, as the co-existence of different population estimates is a source of potential confusion, may damage the credibility of population estimates in the wider public domain, and ultimately affects their utility for conservation and management purposes. Nevertheless, this is not only a problem associated with data and methods used in Carrascal and Palomino (2011), but with data included in BirdLife (2004) in comparison with results obtained by other census programs. For example, BirdLife (2004) provides information for 1,400 breeding pairs for the very well-known *Aegypius monachus* and 8,400-14,300 breeding pairs for *Erythropygia galactotes* in Spain, while two recent studies with specifically designed methodologies suggest, respectively, 2,440 breeding pairs (De la Puente *et al.*, 2007; 1.7 times more) and 160,000-498,000 birds (Seoane, 2005; 6-12 times more, assuming three individuals per breeding pair, two breeders and one floater). Similar very large discrepancies are observed when comparing other species and regions. For example, Summers and Buckland (2011) found that population size of the Scottish crossbill is 4,065-11,350 breeding pairs using a very well designed specific census, while BirdLife (2004) proposes a population of 300-1,250 pairs (9-14 times fewer birds).

Large discrepancies toward higher figures are also found when comparing several species analyzed in Newson *et al*. (2008) with the information available in BirdLife (2004); e.g., *Anas platyrhynchos* (x7), *Fulica atra* (x4), *Streptopelia decaocto* (x2.5), *Muscicapa striata* (x2), *Corvus monedula* (x2), *Sturnus vulgaris* (x4), *Carduelis carduelis* (x3), *Miliaria calandra* (x4.5).

Here I develop a complementary review to that carried out by Murgui (2011) on the available literature on population sizes of Spanish birds, putting the accent on data quality and methods used instead of centering the analyses on data discrepancies. I conclude with a positive, conciliatory, view about large-scale population estimates where limitations of previous works enlighten future research and sampling programs.

WORKS DEALING WITH POPULATION SIZES OF SPANISH BIRDS

Population estimates for Spanish birds in BirdLife (2004)

BirdLife (2004) is a cornerstone for the knowledge of European populations of breeding birds. Data for Spain were mainly obtained from two different sources: SEO/BirdLife (1992) unpublished technical report (unfortunately unavailable in the web; its results are presented in Purroy, 1997), and inferences about the total number of pairs per species in each 10x10 km UTM square surveyed by the last Spanish Breeding Bird Atlas (Martí and Del Moral, 2003). Murgui (2011) summarizes the approaches used by these two works to estimate the total populations of Spanish birds: the combination of published bird densities using line transects for the time span of 1975-1990, stratified in several environmental strata, with the surface areas of these strata in Spain to extrapolate total population size (SEO/BirdLife, 1992); and opinions of the volunteers working for the Spanish Bird Atlas about breeding pairs of species per 10x10 km UTM square (Martí and Del Moral, 2003).

The approach proposed and supervised by F. J. Purroy in SEO/BirdLife (1992) and Purroy (1997) is a signpost for quantitative Spanish ornithology that follows a good and sensible sampling scheme according to the census method (line transects with belts of 25 m at both sides of the observer obtained within the broad timespan 1975-1992), and data analyses (grouping the census data in environmental strata, and making inferences about population sizes multiplying densities by the surface covered by those environmental strata). This pioneering effort in objectively estimating population sizes of Spanish birds twenty years ago has four limitations that were beyond the possibilities of Purroy and collaborators in those dates: small sample size of census database, bias in sampled habitats and geographical location of censuses, lack of detectability parameters to correct density estimations, and unavailability of software and computing power to provide confidence intervals of population estimates. For example, a later review of similar data by Tellería *et al*. (1999) provides only 137 censuses distributed across 25 environmental categories (five coarse-grained habitat groups x five bioclimatic layers), which is considered insufficient to calculate average relative densities of many species in describing their habitat preferences and distribution patterns. As a consequence, it is expected that true population sizes will be significantly larger than those estimated by SEO/BirdLife (1992) for species whose preferred habitat types were not previously well surveyed (e.g., urban environments, reforestations in the Mediterranean region, several kinds of Mediterranean scrublands; see also Newson *et al*., 2008 for the United Kingdom). This should be especially clear for some species with large concentrations in urban areas, because population sizes in SEO/BirdLife (1992) were largely derived from bird densities in less-preferred habitats (see Murgui, 2011 for Spain, and Newson *et al.*, 2005 and 2008 for the United Kingdom).

The available data on bird censuses do not allow for the attainment of detectability measurements, as only contacts (both auditive and visual) with birds within the belt of 25 m at both sides of the observer were considered. The low efficiency of line transects with fixed census belts such as 25 m is well recognized, as is its bias toward the underestimation of true population sizes at large spatial scales (Hildén and Laine, 1985 and references therein). On the other hand, line transects census individual birds and not breeding pairs, and the translation of individual contacts to breeding pairs is a complex endeavor deserving a great deal of work and justification (see for example Estrada *et al.*, 2004).

Martí and Del Moral (2003) provide information about the number of breeding pairs per 10x10 UTM square suggested by thousands of amateurs that contributed to the Spanish Bird Atlas. They used a logarithmic scale of base 10: five categories of 1-9, 10-99, … > 9,999. Martí and Del Moral (2003) do not provide any clear indication about sampling effort per UTM square (i.e., hours or days devoted to prospecting the squares), similarity between sampled and available habitats, methods used to count birds, detectability corrections, or criteria to estimate breeding pairs from bird counts. In a sensible consideration of these limitations, Martí and Del Moral (2003) are emphatic recognizing that the suggested population sizes should be considered as minimum estimations of breeding populations of Spanish birds ("… *estima mínima de población reproductora a escala nacional* …"; using bold type in the original text). De la Puente *et al.* (2007) exemplify the problems inherent to direct estimations of breeding pairs while not taking into account sampling effort, census dates and detectability for a very well known and detectable species such as *Aegypius monachus* (1,400 breeding pairs in BirdLife, 2004 *vs.* 2,440 pairs in De la Puente *et al.*, 2007). In the same vein, Katzner *et al.* (2011) have found that population estimation of *Aquila heliaca* derived from non-invasive genetic techniques, with good methodological and analytical support, was 326% larger than the 127 birds visually observed in direct and exhaustive prospections of a relatively well known nature reserve in Kazakhstan.

These two sources of information are synthesized in a single population estimate for each species in BirdLife (2004), without any clear indication of how both estimations (if available) are combined. Confidence intervals are not based on mathematical aspects related to sample sizes, variability of estimates, etc; therefore, they are meaningless when providing comparative information about the reliability of population estimates. BirdLife (2004) informs about the reliability of the data for each country and species using three categories. For the 95 species analyzed in Carrascal and Palomino (2008), and considered by Murgui (2011), the assigned category is "poorly known, with no quantitative data available" (indicated in the species accounts with normal text and bracketed). BirdLife (2004) recognizes that particular caution should be applied when using any individual figure based on poor, non-quantitative data, because individually they may be subject to considerable error (see Box 3 in page 14 of the cited work). These concerns are surpassed by Murgui (2011) when comparing data on Spanish bird populations extracted from BirdLife (2004) with those included in Carrascal and Palomino (2008), as he equates the quality and meaning of both sources of data.

Nevertheless, and despite of these cautionary notes, I recognize that the pioneer work developed by SEO/BirdLife (1992), Purroy (1997) and Martí and Del Moral

(2003) represents a paramount effort of innovation in the Spanish ornithology, in trying to provide reasonable information about population estimates (at least for minimum population sizes) in a very important and diverse region of the western Palearctic.

Population estimates of Common Breeding Birds using the SACRE program

Carrascal and Palomino (2008) followed the same approach previously defined by F. J. Purroy and collaborators (SEO/BirdLife, 1992), but used a considerably larger sample of bird censuses, a better scattered spatial dispersion of sample units, calculated densities by taking into account 'average' species detectabilities, and applied available mathematical procedures using modern computing platforms to estimate confidence intervals of population sizes (very limited in their use in the early nineties of the past century). The approach and design followed by Carrascal and Palomino (2008) are also very similar to those used in other European regions (e.g., The Netherlands, Sierdsema and van Loon, 2008; Catalonia, Herrando *et al*., 2008; Germany, Droeschmeister *et al*., 2010). Carrascal and Palomino (2008) used data from the SACRE program for three consecutive breeding seasons (2004, 2005, 2006). Data from this monitoring program have been used in scientific research and have been published in international peer-reviewed journals (e.g., Gregory *et al*., 2007; Seoane and Carrascal, 2008; Butler *et al*., 2010; Jiguet *et al*., 2010). Moreover, this large-scale long-term monitoring program, based upon a "citizen science scheme", is an efficient scientific tool which is furthermore highly cost-effective (Jiguet *et al*., 2011).

Data were obtained for 594 UTM squares of 10 x 10 km scattered throughout the Spanish sector of the Iberian Peninsula. On average, each UTM square was repeated in 1.74 years. The census method was point counts lasting 5 minutes, without any limit of detection. Point counts were repeated in two different occasions in each breeding season, although only one count was considered for each UTM by square considering the breeding phenology (i.e., in order to avoid non-established migrant individuals, to diminish the census of yearlings, …). Fieldwork was conducted by more than 600 skilled birdwatchers that had previously participated in the SACRE program, thus having considerable experience with both the census method and species. This is the largest sampling effort ever made in Spain for objectively estimating populations of terrestrial birds during the breeding season, as it is the result of 2067 (=594*1.74*2) fieldwork days. Assuming maximum detection distances ranging from 400-75 m for the most (e.g., *Corvus* spp) and least (e.g., *Regulus ignicapillus*) detectable species (e.g., Buckland *et al*., 2004; Rosenberg and Blancher, 2005), the total sampling effort of SACRE approach implies a census area ranging from 605,000 to 13,000 ha repeated 1.74 times on average, within the narrow time span 2004-2006. This amount of time devoted to censusing birds, and the area covered by the fieldwork, put in a realistic context the concern of Murgui (2011) regarding the small sampling intensity of SACRE approach.

Twenty-twenty one point counts were obtained for each UTM square, totalizing 12,030 census plots for mainland Spain. Point counts were separated a minimum of 1 km apart, and were mainly established on secondary paved roads, or unpaved tracks in agricultural or woodland areas. Point counts were stratified in 22 main habitats and 15 geo-political strata (autonomous communities), that defined 148 environmental strata with at least 10 point counts (and not only 22 strata as summarized by Murgui, 2011). The terrestrial area covered by SACRE was stratified by organizers of the monitoring program by considering a combination of eco-climatic regions and land use, although volunteers finally decided where to locate the census plots. Nevertheless, the correlation between the area available and the number of census plots per habitat was very high for the 15 studied geo-political strata (range of Pearson r: 0.84-0.99), with a weighted average of 0.94 (considering the surface of each autonomous community). To correct for minor inconsistencies between the area available and area covered by the censuses, mathematical procedures applied weights inversely proportional to those deviations in each one of the 15 geo-political strata (i.e., the same approach used for calculating weighted averages). This procedure surpasses Murgui's (2011) concern about Carrascal and Palomino (2008) estimations derived from the potential bias introduced by people, choosing sites that were convenient to access or places which were subjectively regarded as representative or as the best places for birds.

Carrascal and Palomino (2008) devoted 14 pages (with five figures and one large table) to propose and explain an alternative method for the estimation of effective detection radius (EDR) to calculate absolute densities, using a mathematic (integration calculus) and a simulation approach. The proposed approach is a shortcut to obtain reliable estimations in extensive multispecific census programs where many volunteers are involved, and is based upon geometric and mathematical properties of distributions describing distances to bird contacts in point counts: the threshold method with a fixed radius. This method is similar to that proposed by Buckland (1987) based on circular plots, but results in a nearly perfect relationship between 'true' (known by the researches generating the data) and estimated effective detection radius. Carrascal and Palomino (2008) provided the equations to estimate EDR for two threshold distances of 25 m and 50 m, so they are readily available to test their validity using real data and more elaborated approaches such as distance sampling (Buckland *et al.*, 2004). The advantages of this methodological shortcut to obtain EDR is that volunteers participating in the census program are not obligated to estimate detection distances for every bird contact, and it avoids measurement errors that show nonlinear relationships to distance. Also, the method circumvents the fact that observers are usually unable to correctly differentiate distances beyond 65 m (Alldredge *et al.*, 2007).

Forty expert birdwatchers and researchers participating in the SACRE program were asked to distinguish between detections of birds at less or more than 25 m from the count point. This approach minimizes the errors in distance estimation that may have a large influence on density estimates since the area sampled increases geometrically from the central counting point (one of Murgui's 2011 concerns), as the restricted group of ornithologists were asked to be highly trained to estimate 'only' 25 m. Effective detection radius for 95 species were estimated, and the obtained figures were assumed to be representative of the 'average' detectabilities of the remaining volunteers participating in the SACRE program. Effective detection radius in point counts equals the product of maximum detection distance (MDD) by the probability of detection up to that distance (Buckland *et al.*, 2004). Thus, EDR is always lower than MDD and is the proper parameter to estimate densities, and not MDD as erroneously suggested by Murgui (2011). For example, Rosenberg and Blancher (2005) divide bird counts by the maximum detection distance, but multiply this quotient by a correction factor ranging from 1.04 to 22.3 that takes into account detectability in order to estimate densities (the inverse of probability of detection up to MDD equals the correction factor).

Finally, Carrascal and Palomino (2008) devoted 15 pages to explaining the calculation of absolute densities (individuals/km^2) in each habitat and geo-political stratum, absolute densities in 74 environments (considering habitat structure, altitude and bioclimatic layers), and population estimates in each autonomous community and in mainland Spain. They provided 90% confidence intervals of population estimates for each species using randomization techniques (bootstrapping; Davison and Hinkley, 1997), thus avoiding the subjective intervals of previous estimations of population sizes of common breeding birds in Spain. The confidence intervals include the variance attributable to sample sizes, the variability in detectability estimations, the volunteers variability in counting birds, and the variance in bird abundance among different strata and among census plots within each stratum. An external test of population estimates was developed, using the data for Catalonia (Estrada *et al.*, 2004) as the control data. Detailed information on sample sizes, surface of each habitat in every geo-political strata, average data for bird counts, and the 4-10 largest absolute densities for each species are presented in four long appendixes and 95 tables.

Limitations of the approach based upon SACRE data

Nevertheless, estimates for Spanish populations of common breeding birds derived from SACRE data have several limitations that should be acknowledged. First, a large proportion of point counts were established on, or were very near to, paved roads or rural tracks transitable by motor vehicles. If roads influence the occurrence of birds (e.g., Brotons and Herrando, 2001; Bautista *et al.*, 2004; Palomino and Carrascal, 2007; Benítez-López *et al.*, 2010), then population estimates are biased (mainly toward lower population estimates, as bird densities usually decline with their proximity to infrastructure).

Second, double-counting is a common problem in point counts. At high bird densities the observer may be swamped by the number of birds to be located, recognised and counted, and thus it may be very difficult to separate the individuals previously recorded (Bibby *et al.*, 2000). Although this problem is considerably reduced with 5 min length point counts, there is a possibility that some less experienced volunteers participating in the SACRE program have incurred in this problem, therefore inflating bird numbers. Nevertheless, population densities in these habitats provided by Carrascal and Palomino (2008) for many species in northeastern Spain are very similar to those presented by Estrada *et al.* (2004) for Catalonia.

Third, data for several very mobile species should be considered with caution, as point counts are mainly designed for stationary contacts. This could be a concern with birds such as *Apus apus*, *Merops apiaster*, or Hirundinids, whose population estimates are probably inflated to some unknown degree. Nevertheless, this problem is also present when using line transects.

Fourth, there is evidence suggesting that point counts are less accurate, or produce higher figures of population densities, than line transects (e.g., Järvinen, 1978; Buckland, 2006; Cassey *et al.*, 2007; Cai *et al.*, 2010). Moreover, Buckland (2006) shows that less hours of fieldwork are needed to achieve the same coefficient of variation of estimated densities using the line transect than 5-min point counts. Perhaps this is the reason why many census programs use methods based on line transects instead of point counts to estimate population sizes at large spatial scales (e.g., Estrada *et al.*, 2004 for Catalonia; Newson *et al.*, 2008 for the United Kingdom; Droeschmeister *et al.*, 2010 for Germany).

Fifth, although the correlation between the area available and the number of census plots per habitat was very high for the 15 Spanish geopolitical strata, the spatial distribution of sampled 10x10 km UTM was not conveniently sparse in some regions (e.g., Galicia, Extremadura, Catalonia). This spatial bias could affect population estimates of some species in some regions according to the location of the borders of their distribution ranges.

Lastly, Carrascal and Palomino (2008) used weighted averages of absolute densities considering the area of 148 environmental-geographical strata. If mean densities are skewed in some strata (i.e., heavily influenced by large local counts in few samples), then total estimations are influenced by those local maxima. This problem could be of especial concern when working with low sample sizes in some very heterogeneous landscapes, such as urban enviroments, riparian woodlands and agricultural areas, where bird abundance of many species changes abruptly with changes in habitat structure (Palomino and Carrascal, 2005, 2006; Murgui, 2009). An alternative method is to derive predictions of species abundance using spatial modeling with geographic, climatic and landscape variables (e.g., Estrada *et al*., 2004 for Catalonia). Seoane *et al*. (2010) illustrate the contrasting results of both analytical approaches with *Saxicola dacotiae* in Fuerteventua island, showing that weighted averages produce larger figures than environmental modeling. Although some relevant ecological variables, such as food availability (e.g., Alonso *et al*., 1991; Penteriani *et al*., 2002; Tellería *et al*., 2008), are not readily available to be included as predictor variables in modeling techniques to determine bird abundance, this is probably a better approach for large-scale population estimates.

PRECONCEIVED NOTIONS ABOUT METHODS AND POPULATION SIZES

Murgui (2011) clearly shows the large discrepancies between national population sizes obtained by Carrascal and Palomino (2008) and those presented in BirdLife (2004), the former being considerably higher. Murgui (2011) states that these discrepancies are of considerable concern, because "the coexistence of differing population estimates is a source of potential confusion and potentially damages the credibility of population estimates in the wider public domain, ultimately affecting their utility for conservation and management purposes". Although Murgui (2011) does not link BirdLife (2004) population estimates for Spain with a 'golden standard', some of his examples and interpretations of the available data tacitly assume some 'superiority' of BirdLife over the approach based on SACRE data, on the basis that the latter's estimations are, on average, five times larger than those summarized in BirdLife (2004).

A first preconceived and generalized notion is that birds are or should be scarce. For example, 163 million sparrows *Passer domesticus*, 6.4 million of azure-winged magpies *Cyanopica cooki* or 0.34 million of hawfinches *Coccothraustes coccothraustes* are interpreted by Murgui (2011) as debatable and heavily distorted towards unrealistic, very large, numbers, in comparison with 'average' estimations of, respectively, 9.5, 0.5 and 0.013 millions of birds for the above mentioned species provided by BirdLife (2004). Nevertheless, and considering the tight inverse relationship between body mass and population abundances in terrestrial vertebrates (Gaston and Blackburn, 2000; see Carrascal and Tellería, 1991 for maximum ecological densities and body mass of terrestrial birds in northern Spain), what is very surprising is the very low population sizes of these species in mainland Spain according to their body masses (28-72 g) in comparison to: 42.9 million spaniards (approx. 70,000 g), 57.6 million domestic rabbits (approx. 2,200 g), 24.5 million pigs (approx. 95,000 g), 19.4 million sheep (approx. 60,000 g), 6 million cattle (approx. 500,000 g), or … 712 million hens (approx. 600 g) (sources: Instituto Nacional de Estadística, and Ministerio de Medio Ambiente y Medio Rural y Marino for 2008). According to data in Carrascal and Palomino (2008) for 95 very common and widespread bird species in Spain, only two species have populations between 50 and 200 million birds (*Passer domesticus* and *Sturnus unicolor*, two species tightly linked to anthropic environments such as urban and agricultural habitats), seven species have populations ranging from 20-50 million birds (e.g., the widespread *Galerida cristata* in agricultural areas), seven species are within the range 10-20 million (e.g., the very common and generalist *Parus major*), 15 species with 5-10 million (e.g., *Columba palumbus*), and 36 species have populations ranging 1-5 million birds (e.g., *Regulus ignicapillus*, one of the two smallest bird species in Europe, and a generalist of many woodland areas).

Three reasons could explain the tendency to accept low population sizes of wild birds as reasonable:

(1) Anchoring effect of previous estimations lacking good sampling and analytical designs.
(2) Limitations to arriving at true population sizes without applying rigorous and repeatable methods.
(3) Preconceived ideas about rarity of species in their habitats due to scant field experience with them as well as not considering the available literature on habitat preferences and bird abundance.

The anchoring effect refers to a cognitive bias in decision making, and describes the human tendency to rely too heavily on specific pieces of information that govern mental processes involved in thought or calculus during normal decision-making (Tversky and Kahneman, 1974; Piattelli-Palmarini, 1994). Therefore, the information learned at an early stage (e.g., previously published information about population sizes of birds or species scarcity in a region) affects or adjusts the decision about the analysis of the available information under conditions of uncertainty, using instinctive rules of thumb or heuristic approaches (e.g., birds detected while walking through a UTM square for a bird atlas program with a complete lack of standardized sampling methods). Once the "anchor" is established, there is a subsequent bias toward that previously established value. Thus, if previously published information established low population sizes or informed that a species was very scarce in a particular region (e.g., Purroy, 1997), amateur birdwatchers are "anchored" to those low figures in subsequent programs (e.g., Martí and Del Moral, 2003).

Population estimates from atlas volunteers are based on the perceived population levels derived from a complete lack of standardized methods that suffer from many sources of bias. For example, different volunteers have different identification skills based upon distant calls of unseen bird individuals (a large proportion of contacts with birds for many small-medium-sized common birds); there is a complete lack of reference to the detectability concept (i.e., birds detected are an unknown fraction of those present and detectabilities change enormously among different species); there is no true control about the similarity between habitats sampled and available over large UTM squares of 100 km^2; some unknown part of the time devoted for sampling birds is not employed in the best hours according to the maximum detectability of many common bird species, etc. Moreover, assuming an average time devoted per 100 km^2 square of 15 hours, an average walking speed of 2 km/h, and maximum detection distances of 75-400 m, the percentage of total area covered would range between 4.5% and 24%, with a probability of detection considerably lower than 66% up to the maximum distance (Hildén and Laine, 1985). Regarding this method, Estrada *et al.* (2004) point out that the methodology tries to capture volunteers' impressions of bird numbers, and thus is subjective and different observers may estimate different bird numbers for the same species and UTM squares, so that is not necessarily true that overestimations compensate underestimations throughout the study region. Moreover, Estrada *et al.* (2004) found that population estimations obtained from atlas contributors' impressions were lower than those derived from a more objective approach based on standardized sampling protocol, detectability corrections, calculus of species densities, and mathematical techniques, especially for those species more abundant. The same bias has been pointed out by Droeschmeister *et al.* (2010) for Germany; they found that for most common and widespread species with stable or increasing trends the projected population sizes derived from objective methods are greater than expert estimates.

All these facts surely were acknowledged by Martí and Del Moral (2003) when they recognized that their suggested population sizes should be considered as minimum estimations of breeding populations of Spanish birds, and not average reliable numbers. Contrarily to that stated by Murgui (2011), BirdLife (2004) is not largely based on studies carried out by professionals, but on some amateur estimations provided by Martí and Del Moral (2003; e.g., *Burhinus oedicnemus, Columba oenas, Streptopelia decaocto, Cuculus canorus, Apus apus, Merops apiaster, Jynx torquilla, Hirundo daurica, Motacilla flava, Saxicola torquata, Cettia cetti, Sylvia hortensis, Coccothraustes coccothraustes*). Moreover, when the "professional" estimates (SEO/BirdLife, 1992; Purroy, 1997) were later updated using additional information, the main source of the new data is Martí and Del Moral (2003) based upon volunteers' impressions on bird numbers, without any clear indication about how those different population estimates were combined. For example, BirdLife (2004) uses data from SEO/BirdLife (1992) to calculate an extremely narrow estimation of 9.3-10.0 million pairs of *Passer domesticus* in Spain, while data available for this species in Martí and Del Moral (2003) is obviated (2.2 million pairs). Conversely, data for *Jynx torquilla* provided by Martí and Del Moral (2003) is included in BirdLife (2004; 10,000-20,000 pairs) while the estimation of 46,000-53,000 pairs obtained by SEO/BirdLife (1992) is not considered.

Preconceived ideas about species rarity due to low field experience with some bird species and low knowledge of available literature is another common problem that may contribute to accepting low population abundances as 'normal', and thus anchoring estimations of population sizes. The comment on azure-winged magpie by Murgui (2011) clearly exemplifies this concern, as he writes "… similar population sizes for azure-winged magpie *Cyanopica cooki* (a restricted-range and relatively rare species) and magpie *Pica pica* (a widespread and abundant species)". Nevertheless, Hagemeijer and Blair (1997) point out that the azure-winged magpie may reach very high densities (2-5 nests/ha); Martí and Del Moral (2003) show that average maximum densities of magpie and azure-winged magpie are very similar throughout a broad spectrum of habitats, although the second species is considerably more abundant in woodlands with trees taller than 12 m; Palomino *et al.* (2011) show that azure-winged magpie in northern Madrid province is a habitat generalist avoiding urban sprawl, whose habitat preferences widely overlap those of the magpie and the jay *Garrulus glandarius*; and Carrascal and Palomino (2008) estimate similar or higher average densities for the azure-winged magpie (121-42 birds/km^2) than for magpie (94-47 birds/km^2) in the five most preferred habitats of both species in mainland Spain, and the average number of birds per point count was considerably larger for azure-winged magpie than for magpie in Andalusia (respectively 0.172 vs 0.048; N = 1544) and Extremadura (respectively 0.563 vs 0.141; N = 634).

Another preconceived notion is that the relevant figure for population sizes is the number of breeding pairs. To estimate population sizes in terms of breeding pairs is very complex if censuses are not focused on nests, and obviates the important role of non-reproductive individuals in population dynamics. Firstly, because amateur or 'professional' ornithologists directly count individual birds and not breeding pairs in census programs of common breeding birds. Secondly, several bird species have mating systems that strongly differ from strict monogamy, or have some fraction of the population that do not breed after reaching complete sexual maturity. For example, *Troglodytes troglodytes* or *Prunella modularis* are polygynous or polygynandrous species (Perrins, 1998), *Passer domesticus* and *Sturnus unicolor* are facultative polygynous species (Veiga, 1992; Cordero *et al.*, 2003), *Aegithalos caudatus* and *Cyanopica cooki* have cooperative breeding systems with helpers (Glen and Perrins, 1988; Valencia *et al.*, 2003), and many species have a cryptic fraction of non-breeders, including floaters and sub-adults, that do not reproduce even though they may be physiologically capable of doing so (e.g., *Ficedula hypoleuca*, Potti and Montalvo, 1991; *Pyrrhocorax pyrrhocorax*, Blanco *et al.*, 2009). Not surprisingly, Newson *et al*. (2008) found that recent population estimates for British birds using distance sampling methods tended to be higher than those obtained by means of direct counts made during the atlas fieldwork for species with a large proportion of non-breeders. Moreover, the occurrence of polygyny and/or cooperative breeding fluctuates widely across years and localities, and it is very difficult to define correction indices to translate individuals counted to breeding pairs. The conversion of individual birds to breeding pairs requires some convincing assumptions and complex methods (e.g., Estrada *et al*., 2004), and therefore the data in BirdLife (2004) for breeding pairs in Spain are very unrealistic and unbelievable.

Finally, another common preconceived notion is that animals are restricted in their distribution patterns to areas where organizers of census programs and birdwatchers decide to sample, assuming that they are not present, or must be too scarce to be considered, in those areas not visited. The contrasting results obtained by García del Rey (2009) and Seoane *et al.* (2010) on population size of the endemic Canary Islands stonechat *Saxicola dacotiae* clearly illustrates this problem (populations of 832-1,287 and 13,376-15,492 birds, respectively). Both studies used the same distance sampling method to estimate bird abundance. However, the sampling effort of García del Rey (2009) was considerably lower (60 km against 736 km of transects made by Seoane *et al.,* 2010) and he underestimated the potential suitable areas in the island (just 19.5 km^2 in an island of 1,665 km^2) considering that the Canary Islands stonechat inhabits only a very narrow set of ecological conditions. García del Rey's (2009) study did not consider as potential sites several locations where stonechats were recorded by Seoane *et al.* (2010) with high densities, and where the species was previously found according to the available literature. García del Rey's (2009) study further cuts the already underestimated potential range by including within the sampling universe only the conditions he assumed represent probably the only habitat available for the stonechats in Fuerteventura. Nevertheless, Seoane *et al.* (2010) found a large proportion of stonechats outside the restricted environmental conditions of slope, altitude and shrub cover selected by García del Rey's (2009), although average densities of the Canary Islands stonechat in those best habitats were nearly identical in both studies.

TOWARDS IMPROVED METHODS FOR POPULATION SIZE ESTIMATIONS

From the previous review of the available literature dealing with population sizes of Spanish birds, some recommendations could be pointed out.

1) As we lack reliable baselines on actual population sizes for most widespread species in Spain, the available technical information on bird numbers should be understood in a positive, conciliatory, way and treated as an asymptotic learning process, where limitations of previous works enlighten future research and sampling programs.
2) To attain a better progress in the estimation of national population sizes for common and widespread breeding birds, emphasis should be put in methods instead of in discrepancies among different population estimates. The sources of information being compared or criticized should be properly understood and presented, devoting a lot of attention to sample sizes, homogeneous distribution of samples across landscapes and geographical strata, standardized census methods, detectability issues, and methods of data analysis.
3) National census programs require the participation of large teams of organizers with different skills and duties. Those programs should be envisioned taking into account several conflicting demands according to available economic resources, number and qualification of volunteers, time available, area covered, number of species considered, etc, but census programs should be designed by researchers with broad experience in population ecology, biogeography, modern census methods and statistical analyses (which surely would require a Ph.D. degree and a good profile of scientific publications in international journals).
4) The calculation of detectability of each species in census programs is a must. Several sources of bias are related to methods for the estimation of detectability, but it is better to assume those sources of error than to accept unreliable population sizes derived from approaches that do not take into account the fact that only a fraction of existing birds are detected while censusing birds.
5) Direct censuses of birds in *a priori* selected areas provide good insights on minimum bird populations in those areas, but cannot be used to extrapolate average population sizes for the whole country under study without considering the amount of area actually covered by the census for each species, the habitat preferences of species, the estimation of detectability using well standardized census methods, and the use of analytical techniques to infer population abundance in areas not covered by the sampling programs.
6) Confidence intervals of population estimates, based upon proper analytical techniques, should be mandatorily presented besides average population sizes. They inform about the reliability of population estimates that can be used to compare different dates or species. These confidence intervals should be rooted on objective sources of variability according to sample sizes, variance around average detectability, variability in bird abundance across different habitats and throughout spatial units, and within-habitat variation in bird numbers.

7) Population estimates should be based on individuals rather than on breeding pairs, because the latter excludes non-breeding individuals that may influence demographic processes. If breeding pairs is chosen as the currency for population sizes, methods translating individuals counted to breeding pairs should be clearly stated.
8) External data on population sizes at regional level should be used to test the validity of population estimates obtained at larger spatial scales (e.g., nations). The data for those 'controls' should be derived from sampling programs with good design, clearly defined and repeatable census methods, and proper analytical approaches.
9) Data for Spanish birds in BirdLife (2004) should be considered with caution, as they refer to poorly known populations with scarce quantitative data available, and they probably show minimum population sizes, therefore being heavily underestimated. This is a common general pattern when comparing data available in BirdLife (2004) with more recent inventories using better sampling protocols and analytical methods.

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